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# Dredging Research Technical Notes

## Dredge Production Meter Survey

### Purpose

This technical note summarizes results of a survey conducted to identify the instruments used to measure dredge production. Subjective information on meter uses and reliability is also presented.

### Background

Primary instruments in the family of dredge monitoring devices are those of the dredge production meter system. The system consists of a velocity meter, a density meter, and an output display which indicates dredge production in units of volume or mass per unit time. Output signals from these primary instruments are often used to control other instruments such as the Automatic Light Mixture Overboard (ALMO) device. Successful dredge monitoring depends on reliable and properly functioning primary instruments.

A survey was conducted to identify what instruments are being used to monitor and measure dredge production and, using this information, instrument accuracy and reliability were assessed. This information will prove useful to new and prospective users of production meters for planning, purchasing, operating, and maintaining these devices.

### Additional Information or Questions

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## Introduction

One of the tasks of the Dredging Research Program (DRP) work unit entitled "Production Meter Technology," was to identify dredge production meter users and assess the types of instruments used, the frequency of use, and the successes and problems encountered. To accomplish this task a contract was awarded to the Texas A&M Center for Dredging Studies under the direction of Dr. John B. Herbich to conduct an information survey of the use of production meter systems on dredges. The study consisted of a literature search for information on production meter instruments and uses, and a survey of production meter use, supplemented by instrument manufacturers' information and site visits to manufacturing plants and several working dredges. All the information from the responses and field visits was compiled and analyzed to develop an understanding of the extent of production meter use and acceptance.

## Survey Information

Surveys were mailed to 472 foreign and 197 United States dredging organizations (including Corps of Engineers District offices). Of those 56 that responded, 32 organizations (14 foreign and 18 US organizations) used some type of production monitoring instrumentation on the 72 dredges they operate. Also reporting were 24 organizations (8 foreign and 16 US organizations) that, at the time of the survey, had no production measuring instrumentation on their 51 dredges. This indicates that 59 percent of the dredges represented in this survey used some means of monitoring dredge production, an increase over a 21 percent instrument usage response to a similar survey conducted by Dr. Herbich in 1980 (Herbich 1980).

The survey gathered information on the type and size of dredge; the type of velocity, density, or production meter; the instrument manufacturer and year purchased; the type of output display; and the units in which velocity, density, and production were recorded. Information was also requested on how often the instruments were used during dredging operations, the percent of that time they were considered reliable, the frequency of maintenance and repair, modifications, specialized skills of crew members required to operate or service the instruments, use of information by the leverman and project engineer, and general satisfaction with the system as a whole. Some of these responses were very subjective. However, the information presented is as perceived by the user and must be considered in that light.

The data summarized in this technical note are from the 32 responding organizations that use production instrumentation. For simplification, the dredges are classified as to type (hopper or pipeline) and country of

operation (foreign or US organization). The side-cast dredges are included with the hopper dredges because they are self-propelled vessels not encumbered by a long discharge pipeline and they operate in open waters using trailing suction dragheads. The dustpan is included with the pipeline dredges because it has some length of floating pipeline and operates in the more protected river environment. The types of dredges are listed in the following table.

Table 1

Dredges with Production Monitoring Instruments

| | Foreign | US | Total No. (percent) |
|---|---|---|---|
| Hopper | | | 37 (51) |
| hopper | 21 | 14 | |
| sidecaster | 1 | 1 | |
| Pipeline | | | 35 (49) |
| cutterhead | 18 | 16 | |
| dustpan | 0 | 1 | |

The pipeline dredges ranged in size from a discharge pipe diameter of 8 in. inside diameter (ID) to one as large as 45 in. Most of these dredges were in the 8- to 16-in. and 24- to 36-in. range. The size of the hopper dredges, as measured by the capacity of the hopper bin, ranged from 500 to 16,000 cu yd with the majority being in the 2,000- to 6,000-cu yd size range.

## Instrumentation Used

As previously indicated, a complete production meter system has three major components--a velocity or flowmeter, a density gage, and a production output display. Of the 72 dredges considered, 52 (72 percent) had complete production meter systems. This number includes three dredges that indicated the presence of a production meter system but did not specify the individual components. Six dredges (8.5 percent) had velocity and density meters, but were incomplete systems because they did not have the third system component--a displayed or calculated production rate output. Thirteen dredges (18 percent) used only velocity gages and one dredge (1.5 percent) used only a density gage to evaluate dredging performance. Figure 1 shows the dredge instrumentation used by foreign and US pipeline and hopper dredges.

The most frequently reported combination of velocity and density gages was the magnetic flowmeter and nuclear density gage. Thirty-six of the fifty-two dredges, representing 69 percent, with production meter systems used this combination (21 hopper and 15 pipeline dredges). Ten dredges, representing 19 percent, used a doppler flowmeter with a nuclear density gage (6 hopper and 4 pipeline dredges); three pipeline dredges, two with doppler flowmeters and one with a magnetic flowmeter, representing 6 percent, were combined with an unspecified nonnuclear density device; and three hopper dredges, representing 6 percent, used unspecified combinations. Figure 2 illustrates these data for foreign and US dredges.

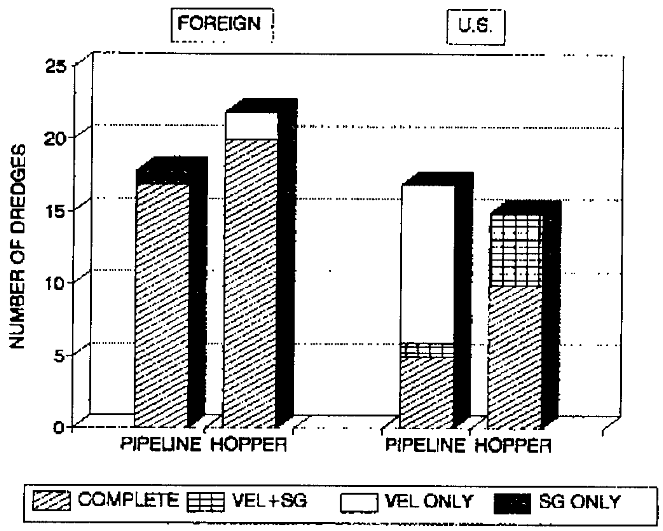


**Figure 1. Instrumentation on foreign and US dredges; VEL means velocity and SG means density (specific gravity)**

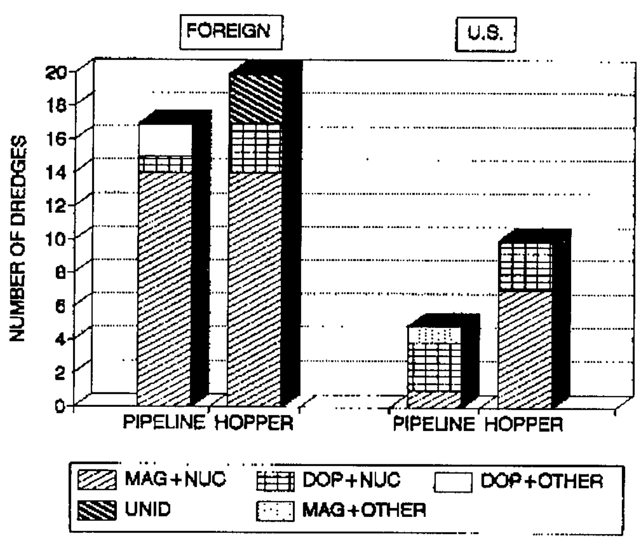


**Figure 2. Foreign and US usage of production meter systems; MAG means magnetic velocity meter, NUC means nuclear density gage, DOP means doppler velocity meter, and UNID means unidentified**

Eleven of the thirteen dredges that use only velocity gages were pipeline dredges. They used eight doppler, two magnetic, and one pressure gage to monitor slurry velocity. The velocity meters used on the two hopper dredges were of the pressure gage type.

The single dredge that reported using only a density gage was a cutterhead that used a displacement gage to determine slurry density.

## Production Output

The cross point display for production meter systems was specified as being used on one-third of the dredges. This single display provides three pieces of information to the user. One pointer indicates slurry velocity, another pointer indicates slurry density, and the intersection of the two pointers indicates dredge production rate. Another one-third indicated use of analog displays other than cross point, and the remaining one-third used a range of digital and graphic displays. Many dredges have multi-output displays on board. Although not asked as a specific question, no respondent added information on the use of a computer to store the data in the Additional Information section of the survey.

The most common unit of production measurement used in both foreign and US dredges is the mass flow unit of tons per unit time. While several foreign dredges use both mass and volumetric units, just three used only cubic meters per unit time. Most time units were in hours but some organizations used seconds. Of the responses for the 20 US dredges, 11 used tons per hour (or second); four reported production in cubic yards per hour; and five indicated they expressed production in both mass and volumetric units.

Almost three-fourths of the production instrumentation in use is less than 10 years old. Their use on US dredges is more recent, with 91 percent of the meters having been purchased since 1980 as compared to 59 percent for the foreign dredges. Several different instrument manufacturers were represented in the survey, but the most frequently purchased production meter systems were from IHC Holland N.V. and Texas Nuclear, a Division of Ramsey Engineering Co. The foreign dredges used IHC instrumentation on 62 percent of the dredges, while the use of that instrumentation on US dredges was only 30 percent. Texas Nuclear instruments were used on 35 percent of the US dredges with the remaining systems coming either from other manufacturers or developed in-house.

## Use, Maintenance, and Repair

Once installed, production meters are used almost all the time during dredging operations. Over three-fourths of the dredge operators claim they use this instrumentation over 90 percent of operating time. The foreign dredging organizations, who have had more experience with this type of instrumentation, were more conservative in their rating of instrument

reliability. Half of the foreign respondents gave an 80 to 90 percent reliability rating to the instruments, while one-fourth rated the system as 90-100 percent reliable. Two-thirds of the US dredge operators rated their instruments as 90-100 percent reliable.

Only one-fourth of the instruments are maintained every 1 to 6 months. All others reported maintenance annually or as needed. Instrument repair for over half of the meters also was on an annual or as-needed basis. However, almost one-third indicated the need for repair as frequently as twice a year. Some commented that repair services were difficult to get, and over three-fourths of the dredges required assistance from the instrument manufacturers at some time. Almost one-third of the dredges had electronics technicians on board, some with special training from the manufacturer, who were capable of doing minor repairs. These dredges were mainly hopper dredges whose dredging schedules are such that land-based repair facilities are not always accessible.

Dredge operators on the whole were satisfied with the system as installed and only a few, less than one-fourth, have modified the system to meet their specific needs.

## Performance Rating

When asked to rate the production meter system on a scale of 1 to 10, with 10 being a perfect system, 13 percent (all of them US dredges) considered their system worthy of a 9.5 to 10 rating. Twenty percent (mostly foreign) rated their system a 9, and 33 percent (almost equally US and foreign) gave an 8 rating to their instrumentation. In all, 82 percent of the instrumentation had a 7 or better rating. This rating is highly subjective and reflects the personal and professional views of the individual who completed the survey. However, it does indicate an acceptance and general satisfaction with production meter systems by those responding to the survey. There were criticisms of some systems with 5 percent of the ratings being 0 or 1, the lowest rating possible. Older instruments and products from certain companies generally received the lower ratings. This seems to reflect the improvements that have been made in the newer versions of production meter instruments.

## Uses of Production Meter Information

The final part of the survey attempted to identify how the production meter information is used. As anticipated, all the dredge operators who have production meter information available use this information to help increase the density of the pumped slurry and to increase production. One dredge owner uses the production meter as a training aid for new levermen, while another uses it to evaluate and compare leverman efficiencies. One sidecaster dredge operator uses the production meter to optimize production by varying vessel operating parameters such as vessel speed through the water, pump speed, and digging depth. Some dredgers whose dredges only have

velocity gages, monitor the slurry velocity to maintain a certain critical velocity for their pipeline. This was stressed as especially important when long pipelines were in use.

Ninety-five percent of the responses indicated that dredging project managers and engineers used production meter information to improve production. They also used the information to calculate a relationship between sediment type and production (84 percent), to determine the long-term capability of the dredge (80 percent), and to develop long-term data base records (75 percent). One dredge owner used production meter information to evaluate pipeline purchases, but did not elaborate on how this was done. Also cited was the use of production meter output signals to drive some of the automatic mechanisms on many modern dredges. Another comment was that the production meter was purchased as a tool for the leverman and a means to verify production quantities. Some hopper dredge operators credited production meters as important in preventing pipeline blockage and maintaining high production in the direct pumpout discharge lines.

Only 37 percent of the respondents said that production meter information was used to estimate quantities of dredged material for contract payment purposes. Surprisingly, this response was almost equally divided between US and foreign organizations.

All of the surveys were returned with useful information; some respondents even went beyond the survey questions and elaborated in the Additional Information space provided. Some of these additional comments (along with the country of origin, type of dredge and other comments), are given below:

- The need to develop in-house density measurement became apparent when the speed of automation outdistanced the response or update time of nuclear densities. The ramping built into nuclear density and the delay due to remote locations was much too slow to give good info to the auto-computer (US, 27-in. cutter suction dredge)

- As far as accuracy is concerned there are a few inherent conditions that trouble me. Because we have a sonic velocity meter (doppler) calibration is accomplished with a $2.00 flow stick. Second, specific gravity of solids (in-situ) is an inputted fixed quantity, a value which can vary from one side of the cut to the other. Besides these problems, the production meter remains a beneficial tool and a means to verify production pay quantities (US, 30-in. cutter suction dredge).

- There is a need for reliable and easy to maintain instruments. Unfortunately at present there are no such instruments available domestically. Even the imported instruments are not easily serviceable. Most hydraulic dredges presently rely on vacuum pressure and stack temperature gages to determine their production (US, 33-in. cutter suction dredge with a 1980 purchased production meter which was given the lowest possible

perfection rating of 1; This company also owns a 4,000-cu yd hopper dredge with a 1984 purchased production meter which received a rating of 7).

- When we bought the equipment, the seller did not know much about the theoretical conditions, and we had many problems putting the measuring unit on line (Argentina, 16-in. cutter suction dredge).

- Clients are more accurate with their pay quantities if they know a production meter is on board. A digital readout for production meters is impractical. Analog or cross hairs are better. My preference is cross hairs, giving three readings in one. Sonic velocity meters are cheaper, but I doubt their continuous accuracy (Australia, 14-in. and 16-in. cutter suction dredges).

- Service is extremely slow and expensive (Canada, 26-in. cutter suction dredge).

- Most problems encountered have been due to the less-than-perfect type of cable being used by shipbuilders between transmitters and production units (England, 3,400-cu yd hopper dredge).

## Summary

In the last decade, use of instrumentation to monitor dredge production has increased. While some dredge operators feel the knowledge of only slurry velocity or density is sufficient to maintain pipeline critical velocity or desired slurry density, many dredge owners are installing and using dredge production meter systems. A complete production meter system consists of three major components -- a velocity gage, a density gage, and a production output display or calculation.

This survey of an almost equal number of pipeline and hopper dredges shows some differences in the use of production meter systems by foreign and US dredge operators. However, certain trends are apparent. Hopper dredges are more frequently equipped with complete production meter systems, and foreign dredges (both pipeline and hopper) more often have complete systems than US dredges.

Slurry velocity is almost always measured by either a magnetic or a doppler velocity meter, and slurry density is almost exclusively measured with a nuclear density gage. The most frequently used combination of instruments is a magnetic flowmeter and a nuclear density gage, with the production output going to a cross point, analog, or graphic display. The next combination of choice is a doppler flowmeter and a nuclear density gage.

Production is most frequently measured in mass flow units of tons per unit time, although several US dredges maintain the capability to calculate both tons and cubic yards of material.

Once installed, the production meter system is used almost all the time during dredging operations, and the majority of dredge operators feel the system is reliable over 80 percent of the time. Most maintenance and repair is on an annual or as-needed basis; however, some instruments needed repair as frequently as twice a year. The majority of the systems required service or assistance from the manufacturer at some time. Hopper dredges are more likely to have on board an electronics technician capable of performing minor instrument repairs. Very few instruments have been modified to meet specialized needs of the dredge operator. General satisfaction and acceptance of the system is indicated in the overall performance rating of 7 or higher (10 being a perfect system) given by 82 percent of the survey respondents.

Production meter information is used extensively by the leverman and the project engineer to increase pipeline slurry density and dredge production. The project engineer also uses the system as a leverman training and evaluation tool. Production data are used to better understand the dredging process and to establish a data base for future needs. Only 37 percent of the respondents indicated that production meter information was used to estimate pay quantities.

Production meter systems have been in existence for many years and have had, at times, a reputation for being unreliable and difficult to calibrate. Advances in electronics combined with an urgent need to reduce overall dredging costs have led to an improved series of monitoring instruments, such as production meter systems, which are gaining recognition and approval. Very few, if any, instrument systems are perfect, and all need proper maintenance and care if they are to perform well. Results of this survey demonstrate the willingness of the dredging industry to adopt a new technology and employ it to their advantage.

## Reference

Herbich, John B. 1980. "Operating Characteristics of Cutterhead Dredges," *Proceedings of WODCON IX*, World Dredging Congress, pp 191-202.